REMARKS

Claims 1-13 are pending. By this Amendment, Claims 1-2, 7, 9 and 11-13 are amended.

Applicant gratefully acknowledges the indication in the Office Action that Claims 2-7 and 12-13 contain allowable subject matter.

In the Office Action, the Examiner objects to Claims 9-13. Applicant respectfully submits that the amendments to Claims 9 and 11 obviate this objection. Withdrawal of the objection is respectfully requested.

In the Office Action, the Examiner rejects Claims 1 and 8-11 under 35 U.S.C. § 103(a) over U.S. Patent No. 6,625,216 to Zhu (Zhu) in view of U.S. Patent No. 5,524,845 to Sims (Sims). This rejection is respectfully traversed.

There is no motivation to modify Zhu with Sims. In addition, the combination asserted by the Examiner is non-functional. The reason is that Zhu's disclosed technique can only use a Hadamard Transform, and is incompatible with a Fast Fourier Transform, because Zhu teaches a MAD (Mean-Absolute-Difference) criterion for correlation. The techniques respectively described in the Zhu and Sims patents are totally disjoint to each other, and cannot be used together in any meaningful sense. Furthermore, the image-correlation community has historically treated the MSE (Mean-Square-Error) method in the spatial domain, and the MCC (Maximum Cross Correlation) method in the frequency or Fourier Transform domain, as two independent approaches. Prior to the author of the present invention, no-one in the image-correlation community attempted to investigate differences between the two approaches using detailed mathematical derivations, and for at least these reasons the person of ordinary skill in the art at the time of the invention would not

have arrived at Applicant's invention as variously recited in Claims 1 and 8-11 when considering Zhu and Sims. The reasons for this are described in further detail below.

By way of quick review, in general two approaches for image correlation have been known for years:

(1) The Spatial-Domain Approach

The most common methods used in this approach include the Mean-Square-Error Method (MSE) and the Mean-Absolute-Difference (MAD) Method. Particularly the MSE method is the most standard method used for correlation in spatial domain. The basic mathematical equation used in this method is:

$$C(s,t) = \frac{1}{N} \sum_N [f(x,y) - g(x-s, y-t)]^2$$
$$(s_0, y_0) = \underset{(s,t) \in Window}{Min} [C(s,t)]$$
(1)

The processing involved in correlation computation is the direct use of Equation (1), that is, first taking the squared difference between the corresponding pixel values of the two windows, search window and reference window, and then summing over all pixels within the windows with a normalization by the reference window size. In order to carry out the computation efficiently Equation (1) should be used directly. There is no need to expand Equation (1) into individual terms, because that will lead to more operations by multiplications and additions and thus reduce the speed of processing.

(2) The Frequency-Domain Approach

For years many methods of using frequency-domain transforms, particularly the Fourier Transform, have been proposed for speeding the processing of correlation computation in real-time applications. Specifically the technique of Maximum Cross Correlation (MCC) has been used more often which involves the following Fourier-Transform equation:

$$f(x,y) \xrightarrow[\substack{Fourier \\ Transform}]{} F(f_x, f_y)$$

$$g(x,y) \xrightarrow[\substack{Fourier \\ Transform}]{} G(f_x, f_y) \xrightarrow[\substack{Complex \\ Conjugate}]{} G^*(f_x, f_y)$$

$$R(f_x, f_y) = [F(f_x, f_y) \cdot G^*(f_x, f_y)] \xrightarrow[\substack{Inverse \\ Transform}]{} r(x,y) \qquad (2)$$

$$(x_0, y_0) = \underset{(x,y) \in Window}{Max} [r(x,y)]$$

The MSE method typically used in spatial domain and the MCC method typically used in frequency domain are actually based upon different correlation criteria, not two different implementations based upon same criterion. They have been treated as two independent approaches.

When the background in the image frames is more or less uniform, similar results will be obtained by these two methods. On the other hand if the background is non-uniform, the two approaches will lead to different results. Because the researchers knew that these two methods are derived from different criteria, no-one prior to the author of the present invention made any attempt to find any mathematical relationship between them.

The author of the present invention made significant contributions variously encompassed by Claims 1, 8-9 and 11, including:

(1) Investigation into the difference between the MSE Method and the MCC Method using an analytic approach to find the potential mathematical relationship between the two;

(2) Identification of the cause which contributes to the difference in the results obtained from the two methods in dealing with image frames with non-uniform background and the need of including the background correction term to make the Fourier-Transform approach capable of obtaining the same results as the MSE approach; and

(3) Derivation of a Fourier-Transform equivalent for the background correction term, which can be implemented to improve processing speed for real-time applications.

In contrast, Zhu teaches that MSE and MAD are two of the criteria to be used in correlation computation. Mathematically the MSE criterion is the basic maximum-likelihood measure, which has been proved in the Statistical Estimation Theory to be the optimum criterion used for correlation. The MAD criterion is not a fundamental measure in maximum likelihood testing. It is only a simplified version, which is used primarily for the purpose of improving the processing speed by replacing the operation of taking square by the operation of taking absolute value (see for example Equation (1) and Equation (3) in Zhu). However, Zhu chose to use the MAD criterion in his correlation technique covered by his patent, even though according to Estimation Theory his approach is not the optimum approach.

In addition, Zhu discloses using a combination of MAD criterion with a Hadamard Transform. However, Zhu makes an unproven statement of generalizing

his approach of using MAD criterion with Hadamard Transform to extend to other criteria and other orthogonal transforms. That statement is not supported with any mathematic proof, and as a matter of fact, it is a false statement (as one of ordinary skill in the art would readily recognize), because the detailed mathematic derivations and formulations involved are quite different from one combination of criterion and transform to another combination. It is important to note the difference between Zhu's Equation (1) for MSE criterion and Zhu's Equation (3) for MAD. As pointed out earlier, in Zhu's Equation (1) the operation of squaring is taken over the pixel-value difference within the bracket but in Zhu's Equation (3) the operation of taking absolute value is performed over the pixel-value difference. This major difference eventually leads to very different mathematic results. The expansion of the squared bracket of the MSE equation will lead to a background correction term as disclosed in the present application and recited in the independent claims. However, mathematic manipulation of the MAD equation will not lead to this correction term. As a matter of fact, Equation (3) cannot be further expanded in any mathematically meaningful way.

Furthermore, because of the operation of taking absolute value in the MAD equation, the Fourier Transform cannot be applied here to gain any advantages in implementation or in processing speed in real-time applications. That is why Zhu chose the Hadamard transform because of the nature of this transform more suitable to the absolute-value operation in the MAD equation. Therefore, none of the equations in Zhu discloses or suggests the background correction term recited in the independent claims of the present application.

Sims likewise fails to disclose or suggest any such correction term, and therefore fails to overcome the deficiencies of Zhu discussed above. Furthermore, there is no motivation to modify Zhu with the teachings of Sims, because the person of ordinary skill in the art at the time of the invention would have realized that Zhu's disclosed technique can only use the Hadamard Transform, and is incompatible with the Fourier Transform. In other words, the person of ordinary skill in the art at the time of the invention would have realized that the techniques respectively disclosed in Zhu and Sims are incompatible, completely disjoint to each other and could not have been used together in any meaningful sense.

For at least the above reasons, Applicant respectfully submits that the asserted combination of Zhu and Sims fails to disclose or suggest tracking an object using Fast Fourier Transform and a background correction term that includes a frequency domain sinc function, as recited in independent Claim 1, and similar features recited in independent Claims 8-9 and 11. Dependent Claim 10 is likewise allowable for at least the same reasons. Accordingly, withdrawal of the rejection of Claims 1 and 8-11 is respectfully requested.

Applicant respectfully submits that the application is in condition for

allowance. Favorable consideration on the merits and prompt allowance are

respectfully requested. In the event any questions arise regarding this

communication or the application in general, the Examiner is invited to contact

Applicant's undersigned representative at the telephone number listed below.

Respectfully submitted,

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